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Bump on Tail Instability with non-Maxwellian Distribution Functions

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'Bump on tail' is a micro instability generated when an electron beam is injected into plasma, as a consequence of which the particle velocity distribution function gets a 'bump'・ on its 'tail'. Initially Filbert et al [1], and Papadopoulos et al [2] discussed this idea but both were unable to explain the stabilization of the beam at low energies. Later, Freund et al [3] discussed the more general schemes of beam stabilization in the presence of superthermal background solar wind electrons which is more relevant to the actual circumstances of the foreshock.

A modified concept of bump-on-tail instability saturation was proposed by Klimas et al [4] in the Earth's foreshock regime. With the help of numerical simulation and quasi-linear analysis they argued that the Filbert's mechanism is also operative during the evolution of the bump-on-tail instability. The saturated plasma state represents a balance between its creation mechanism and velocity space diffusion・ and cannot determined by velocity space diffusion alone.

Maxwellian distribution is the natural distribution in case of thermodynamic equilibrium. However observed distribution functions in space and laboratory plasmas, show a significant deviation from the Maxwellian distribution function. Data analysis prove that natural space environment such as chromosphere, solar wind, solar corona, magnetosheath, magnetosphere and astrophysical plasma contains particles which exhibit high energy tails that lead to non-Maxwellian distributions.

The electron velocity distribution function in space is observed to be non-Maxwellian and that is widely confirmed by the data collected from spacecraft [5]. Such non-Maxwellian distributions can be responsible for a lot of different characteristics of plasma waves and instabilities. The increase in energy leads to the formation of high energy tails which can be more precisely described by Lorentzian Kappa (κ) distribution function or may be expressed in power law form as generalized (r, q) distribution function. Such kind of deviations occur when plasma is moderately collisional. Lorentzian Kappa distribution is a convenient thematical choice to study weakly collisional plasmas [6,7].

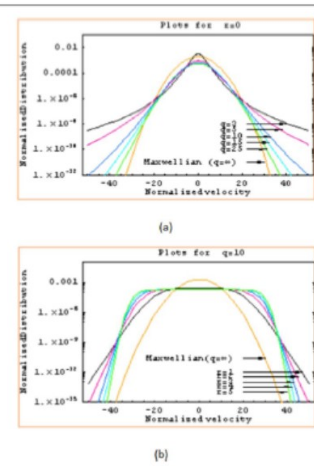

Figure 1. The (a) part shows behavior of distribution function with different values of index q when index r is fixed and part (b) shows fixed value of index q while r varies.

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